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RESEARCH MEMORANDUM

MODEL DITCHING INVESTIGATIONS OF THREE

AIRPLANES EQUIPPED WITH HYDRO-SKIS

(Revised)

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
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MODEL DITCHING INVESTIGATIONS OF THREE AIRPLANES EQUIPPED WITH HYDRO-SKIS

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SUMMARY

Model investigations were made to determine the ditching characteristics of three typical multiengine airplanes equipped with possible arrangements of hydro-ski ditching gear. The behavior of the models was determined from visual observations, acceleration records, and motion pictures of the landings.

It was concluded that a ditching gear of one or more hydro-skis would afford very satisfactory water landings as compared with landings without skis. The best landing with a hydro-ski ditching gear could be made in a near-level (slightly nose-up) attitude although any normal landing attitude would be satisfactory. It is possible that critical damage could be eliminated from ditching by using a hydro-ski ditching gear, thus greatly increasing the chances of survival and rescue.

INTRODUCTION

As part of a hydrodynamic research program on methods of water-basing high-speed airplanes without undue impairment of flight performance, the NACA has investigated the use of retractable planing surfaces called hydro-skis. During water take-offs and landings, the hydro-skis are extended on struts so that the main body of the airplane is not subject to high water loads at planing speeds. In flight they are retracted flush with the surrounding surface.

The concept of hydro-ski landing gears also appears of interest as a positive means of eliminating the hazardous motions and structural damage associated with the ditching of landplanes. This would be of particular interest for transport airplanes. In this case, the gear would be used in a landing only once and a manual arrangement for extending it would be sufficient; hence its weight should be small as compared to that of a normal installation.

A preliminary investigation was made in Langley tank no. 2 to determine the ditching characteristics in calm water of three typical multi-engine airplanes equipped with possible arrangements of hydro-ski ditching gears. The purpose of the investigation was to demonstrate generally the characteristics that could be expected from such a gear as an incentive for more detailed design studies of specific installations. The optimum number, size, and location of the hydro-skis for a given application will depend on the airplane concerned and the degree of effectiveness desired. Such a ditching aid would of course add a weight penalty and its applicability would depend on the safety requirements for the airplane.

APPARATUS AND PROCEDURE

Description of Models

The models were those used in previous ditching investigations of the Lockheed Constellation, the Lockheed P2V-1, and the Douglas DC-4. The Constellation model was 1/18-scale size and the remaining two were 1/16-scale size. The models were constructed of balsa and spruce and were ballasted internally to obtain scale weights and moments of inertia. Since the hydro-skis were intended to support the models clear of the water at high speeds, structural damage was not simulated except on the Constellation model which was also tested with scale-strength bottom sections below the passenger floor.

The size, plan form, and extended locations for the hydro-skis were determined from the present tests and previous experience with hydro-skis as being suitable for the purpose of the investigation. The cross-sectional shape of the ski bottoms corresponded to shape of the fuselage or wing at a location where the ski could logically be retracted leaving the external lines of the airplane unaltered. The ski sizes corresponded to ski loadings of 850 to 1000 pounds per square foot based on the ratio of airplane gross weight to ski area. Higher loadings possibly could have been used successfully.

Test Methods and Equipment

The models were launched by catapulting them from the Langley tank no. 2 monorail so that they would glide freely onto calm water. The models were attached to the launching carriage at the desired landing attitude and the control surfaces were set so that the models would glide onto the water at approximately this attitude. The results of the investigation were obtained by visual observations, from acceleration records, and motion pictures.

Test Conditions

All values given refer to the full-scale airplanes.

Gross weight.- The model weights corresponded to the following values:

Constellation . . . . 85,500 pounds
P2V-1 . . . . 48,000 pounds
DC-4 . . . . 72,500 pounds

Landing attitude.- Various landing attitudes from 2° to 10° were investigated. Attitude is defined as the angle between the smooth-water surface and the fuselage reference line.

Landing speeds.- The speeds used in the tests were computed from lift curves for the various airplanes and ranged from 82 miles per hour to 110 miles per hour. The models were airborne in all landings and the speeds were held within ±10 miles per hour of the computed speeds.

Flap settings.- Each model was tested with flaps full down.

RESULTS AND DISCUSSION

General

Sequence photographs of the models landing with the hydro-skis installed are shown in figure 1. In the near-level landings, the runs were about a quarter-mile long (full scale) and very smooth. In the high-attitude landings, the lengths of runs were shorter and in the tests of the Constellation, slight porpoising was obtained. Any normal landing attitude was satisfactory. The motions were gentle and longitudinal accelerations were small as compared to the ditching behavior without skis. (See, for example, refs. 1 and 2.)

When landed at the 4° attitude, the Constellation model usually ran at an attitude of about 4° or 5° with the model trimming up and the aft fuselage entering the water near the end of the run. When landed at 9°, the model trimmed up slightly at the beginning of the run and usually ran at about 10° with some porpoising. The ends of the runs at either attitude were characterized by a slight nose-down pitching motion probably caused by a loss of suction on the aft fuselage when speed was lost. This pitching motion is not considered of importance.

The P2V-1 model when landed at the 2° attitude generally trimmed at about 1° or 2° during the landing run. The runs were very smooth. The nose-down pitching motion, as mentioned for the Constellation, was present at the end of the run. In this case it appeared that the pitching moment was caused by the drag on the skis when they sank into the water. In a 6° landing the model trimmed down soon after contact and ran at an attitude of about 1° or 2° making a run very much like that of the 2° landing. In a 10° landing the aft fuselage and tail hit the water about the same time that the ski did, and the model made the entire run at a high attitude with the tail in the water.

The DC-4 model made very good runs at both the 2° and 7° landing attitudes. It trimmed up slightly on landing and then trimmed down making the run at approximately the landing attitude. The nose-down pitching motion at the end of the runs was present in the DC-4 landings.

Longitudinal and normal accelerations were measured in landings of the Constellation at 4° attitude and the P2V-1 at 10° and 2° attitudes. The longitudinal and normal accelerations due to landing for both models were very low compared to the accelerations obtained in investigations without skis installed.

The speed at which the skis settled into the water deep enough for the fuselage to be in solid water was low enough that the scale-strength bottom of the Constellation model was not damaged during the tests. The skis, therefore, offer the possibility of eliminating damage during ditching with the result that passengers would not be injured by onrushes of water and the airplane could be made to float indefinitely. This feature together with the low accelerations obtained would greatly increase the probabilities of survival and rescue.

Ski Location

The optimum vertical location of the ski was found to depend on the ski shape, number of skis, fuselage shape, and landing flap position. In general, the amount of spray and the surfaces hit by spray from the skis were important. These characteristics were different for each airplane. The locations shown in figure 1 proved best for the particular installations. In general, the skis should be far enough below the airplane so that at the desired landing attitude they would contact the water before any other part of the airplane. If the skis are too close to the fuselage, the fuselage will come in contact with the water too soon which would partially nullify the effects of the ski. When this was the case, the models porpoised and the runs were much shorter.

Various longitudinal locations of the skis also were investigated and it was found that if the ski were too far forward, porpoising would occur; if too far aft, there would be a tendency to dive.

CONCLUSIONS

Conclusions based on the model ditching investigations of three airplanes equipped with hydro-skis are as follows:

1. A ditching gear consisting of one or more hydro-skis will afford very satisfactory water landings as compared with landings without skis.

2. The best landing with a hydro-ski ditching gear can be made in a near-level (slightly nose-up) attitude although any normal landing attitude is satisfactory.

3. It is possible that critical damage can be eliminated from ditchings by using a hydro-ski ditching gear, thus greatly increasing the chances of survival and rescue.

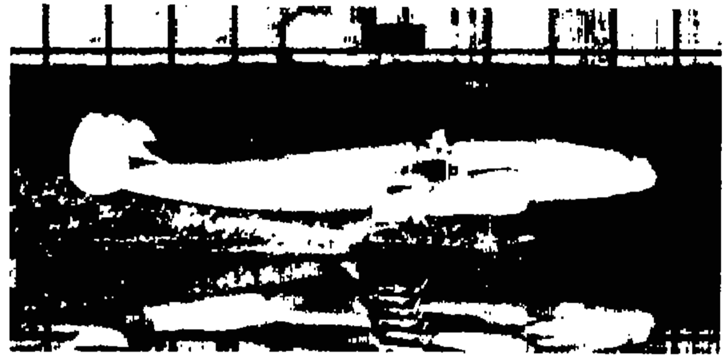
Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., July 10, 1953.

REFERENCES

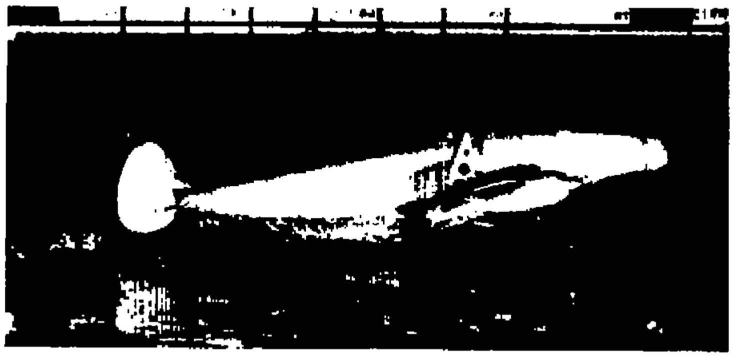
1. Fisher, Lloyd J., and Morris, Garland J.: Ditching Tests of a 1/18-Scale Model of the Lockheed Constellation Airplane. NACA RM L8K18, 1948.

2. Fisher, Lloyd J., and Hoffman, Edward L.: Model Ditching Investigation of the Douglas DC-4 and DC-6 Airplanes. NACA RM L9K02a, 1949

Near contact



662 feet



1132 feet

1255 feet

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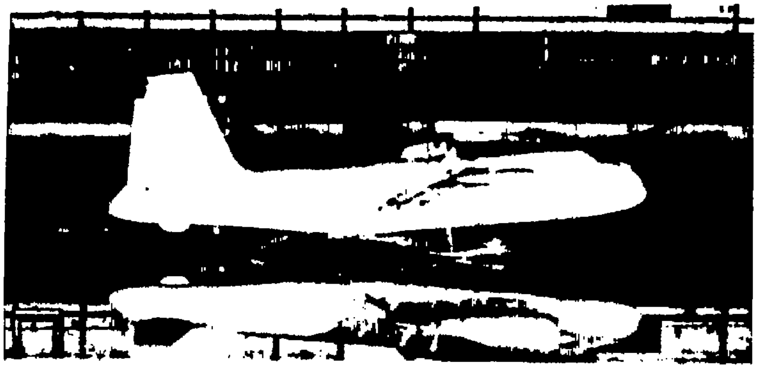
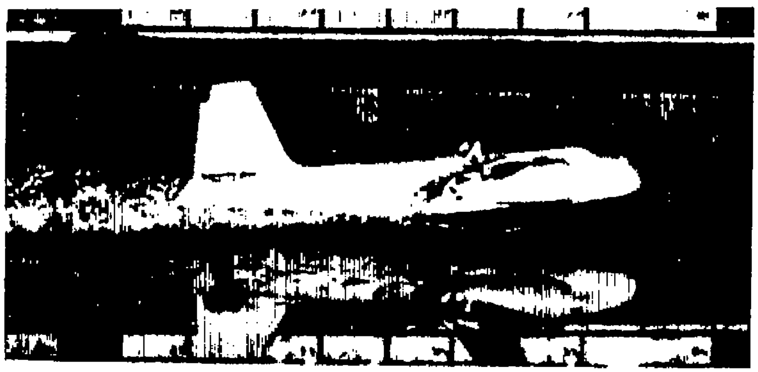
(a) Constallation; landing attitude 4°.

Figure 1.- Sequence photographs of model landings on hydro-skis. Distance after contact indicated in feet, full scale.

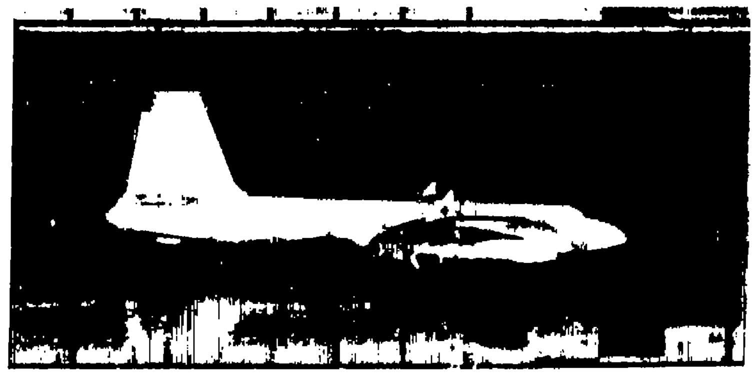


Near contact

552 feet



1310 feet



1400 feet

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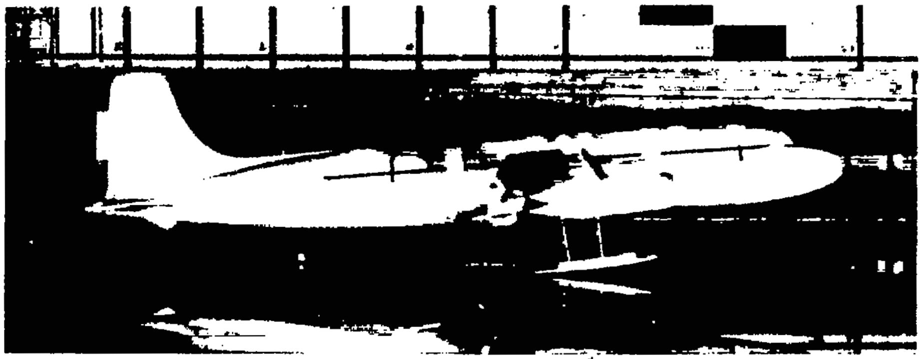
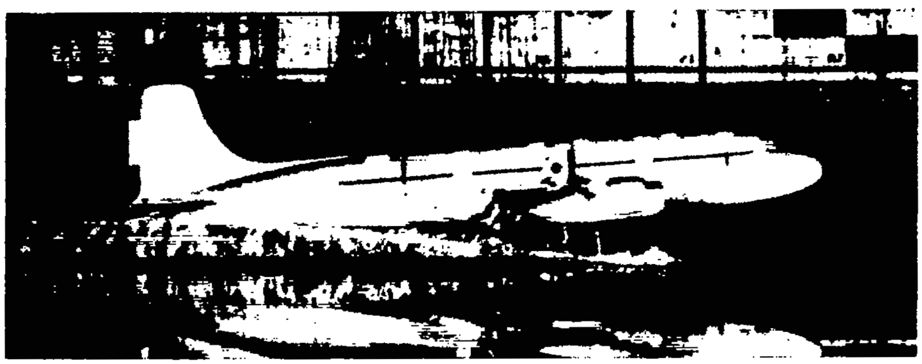
(b) P2V-1; landing attitude 2°.

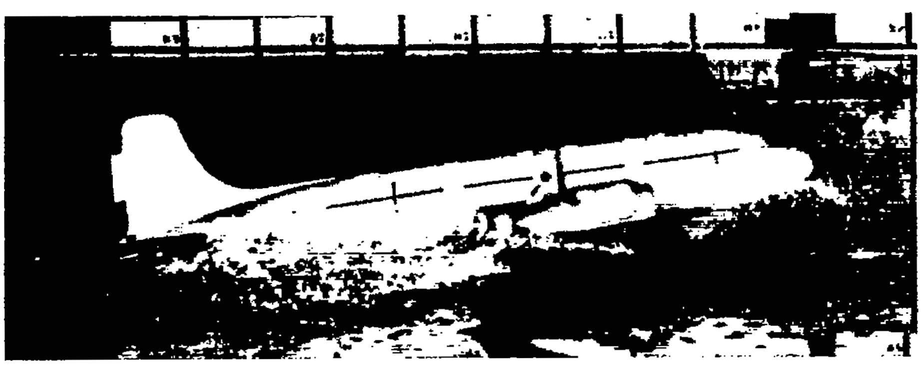
Figure 1.- Continued.



Near contact



640 feet



1136 feet

L-63051

(c) DC-4; landing attitude 2°.

Figure 1.- Concluded.